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A NATIONAL FOCUS OF SCIENCE AND RESEARCH

By George Ellery Hale
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A National Focus of Science and Research

BY GEORGE ELLERY HALE

Honorary Chairman of the National Research Council, Author of "The New Heavens," etc.

ILLUSTRATIONS FROM DRAWINGS BY THE ARCHITECT AND FROM PHOTOGRAPHS

THE stately plan of the city of Washington, conceived by L'Enfant under the personal inspiration of Washington himself, rescued from oblivion and vastly developed by Burnham and his associates, is rapidly assuming material form. The major axis, passing from the dome of the Capitol through the Washington Monument, now terminates admirably in the massive Doric temple of the Lincoln Memorial, which overlooks the Potomac and the heights of Arlington. Flanking it on its left, in the midst of a spacious square facing the Mall, another marble structure, also associated in its origin with the Civil War, is now rising. This is to be the home of the National Academy of Sciences and the National Research Council, organized to promote the progress of science and research for the advancement of knowledge and the national welfare. In this centre the latest scientific and technical advances of the whole country will be shown in a changing exhibit, and investigators will meet to report new results and to consider the interests of research.

THE NEW BUILDING

It has been recognized for many years that the full possibilities of the National Academy of Sciences could not be realized without the aid of such a building. Attempts made before the war to secure the large sum required for construction and endowment were not successful, but in 1919 a gift of $5,000,000 was made by the Carnegie Corporation to permit the erection of a building and to provide an endowment for its maintenance and operation and an income for the work of the Research Council. An entire city block, with a frontage of 530 feet on B Street, facing the Mall near the Lincoln Memorial, was purchased for a site at a cost of $185,000, contributed by friends of the Academy and Council.

Before beginning work on the plans of the building, the general purposes in view were explained to the Federal Commission of Fine Arts and suggestions were requested regarding architects. Bertram Grosvenor Goodhue, of New York, recommended informally as the first choice of the Commission, was appointed architect, and much time and thought were devoted to the design. The attitude of this architect toward his work is a thoroughly scientific one, in keeping with the purposes of the building. The general architectural scheme approved by the Fine Arts Commission for public buildings in Washington is classical, and the proximity of the Lincoln Memorial, a Doric temple, rendered a harmonious treatment imperative. But while retaining the simple and symmetrical elements of classical architecture, Mr. Goodhue preferred not to follow the common practice of lining the façade with a row of detached or engaged columns, supporting nothing but the cornice, and, in his opinion, serving chiefly to exclude light from the windows. The construction of the central hall, which carries a true dome rather than an imitation one; the use of sound-absorbing materials to assure good acoustics; and many other features of the building, illustrate the way in which the architect has accomplished his task.

The main-floor plan is shown on page 520. The portion of the building facing B Street, 250 feet in length, will ultimately form one side of a hollow square,

the other three sides of which will be added when more space is needed.* At the centre of this square is a lofty central hall (page 525) surmounted by a low dome, surrounded by a group of seven exhibition rooms one story in height, illuminated by skylights. The central hall is approached by the public (page 523) through an entrance hall, flanked by large library and lecture rooms, with reading and conference rooms at the east and west ends of the building. The second and third floors are devoted to offices for the Academy and Research Council. In the basement are a large stack-room under the library, a lunch-room and kitchen for the convenience of those at work in the building, a heating and ventilating plant, janitor's quarters, etc.

The sculptural work has been intrusted to the well-known sculptor, Lee Lawrie, who has admirably seized the spirit of the undertaking and embodied it in his designs. The windows of the façade, which overlook a wide terrace and command a superb view of the Lincoln Memorial and the heights of Arlington, are framed in bronze, with large bronze tablets, four feet by nine feet in size, between the first and second floors. These panels will depict the leaders of science, from the Greeks to recent times. The stone pediment of the main entrance, the bronze lamps flanking the terrace steps, and other sculptural features are also being designed by Mr. Lawrie.

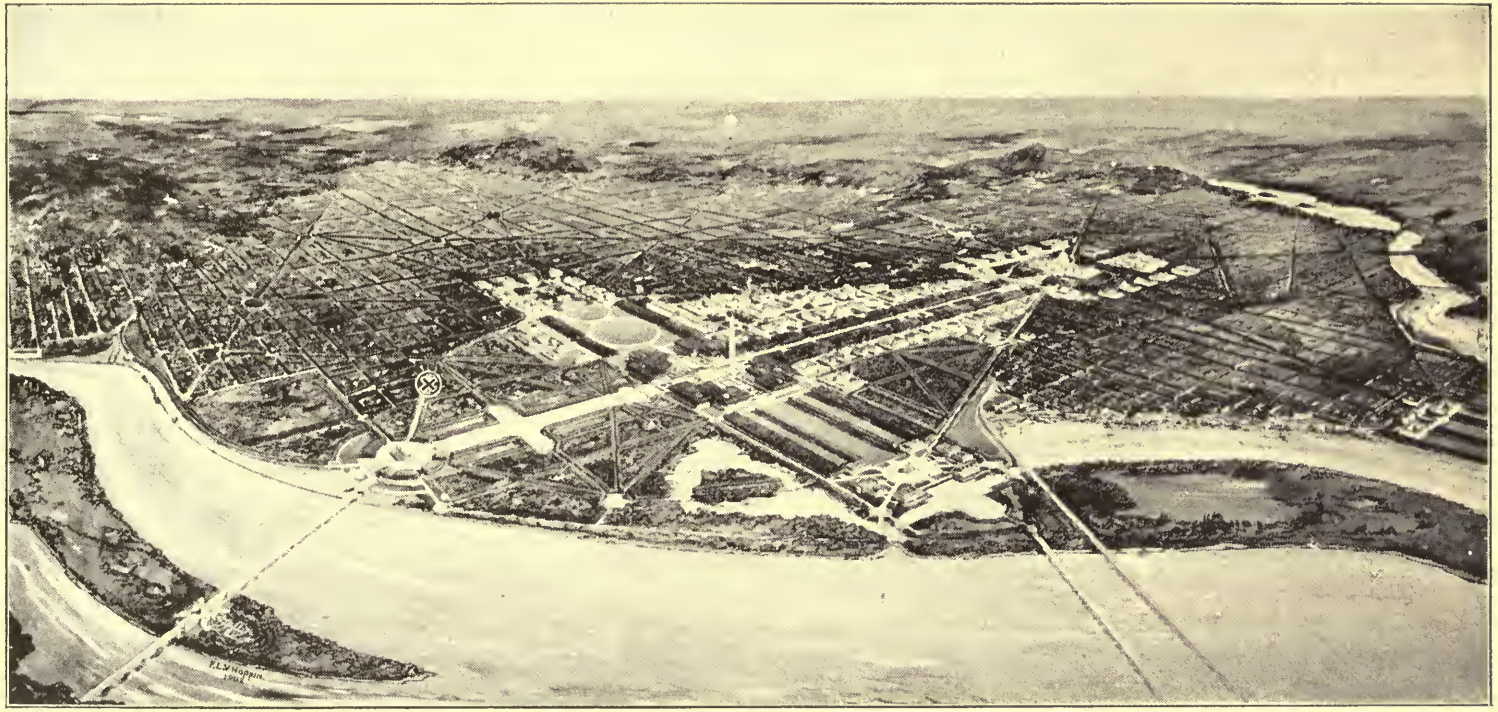
The central hall, though ordinarily employed for exhibits, can be quickly transformed into a large lecture-room, equipped with screen, stereopticon, moving-picture apparatus, etc., seating 550 people (with the three balconies), and serving for the larger public meetings and lectures of the Academy and Council. The smaller lecture-hall, seating 200, is available for other occasions, and the conference and committee rooms will be in daily use by the Research Council.

* The building has a frontage of 260 feet and a maximum depth of 140 feet. Its height above the first floor is 60 feet. The dimensions of some of the rooms are as follows: vestibule, 11 by 20 feet; entrance-hall, 21 by 36 feet; central hall, 24 by 64 feet; library, 36 by 64 feet; lecture-room, 34 by 50 feet. The exhibition rooms surrounding the central hall range in size from 14 by 26 feet to 21 by 34 feet. The total available floor space, exclusive of elevators, doorways, and hallways, is 39,874 square feet.

The library will contain the extensive collection of publications received from scientific societies at home and abroad, together with the reference books of the Research Information Service. As a centre for the many activities organized by the Academy and Research Council the new building will bring together scientific investigators from all parts of the world. It will serve admirably for international scientific bodies when meeting in the United States, and in so far as may prove practicable it will be rendered available for meetings of the many national scientific and technical societies represented in the Research Council.

A MUSEUM OF DISCOVERY AND PROGRESS

One of the prime purposes of the new building is to serve as a means of keeping the public in touch with the progress of science and to demonstrate the importance of research. An illustration based on recent experience will show how this may be done. Within the last few months an extraordinary outburst of interest in wireless telephony has brought radio outfits into tens of thousands of American homes. Most of the apparatus employed has been made by amateurs, who have contributed many novel and useful ideas to the progress of the art. This newly awakened enthusiasm affords a unique opportunity to advance the interests of science and research. The vast majority of the radio amateurs are attracted chiefly by the novelty of the subject, the pleasure of receiving messages from far-away sources, and the opportunity to exercise the mechanical ingenuity innate in so many American boys. Few realize that wireless communication is not the sole creation of Marconi and other inventors, and fewer still appreciate the nature or importance of the fundamental researches of the physicists who made it possible. But all are learning of electrical methods and devices, and better still, those who make their own apparatus are acquiring some of the pioneer spirit and the self-reliance that form the necessary stock in trade of every original investigator. Here, then, is a rare opportunity to discover and develop latent talent.



Proposed plan of Washington, as seen from Arlington.

The main axis passes from the Lincoln Memorial on the left through the Washington Monument and the Capitol. The site of the new building of the National Academy of Sciences and National Research Council, facing the Mall near the Lincoln Memorial, is indicated by a cross within a circle.

One of the exhibition-rooms in the new building will contain the latest forms of radio apparatus, with which the public can receive messages from the most distant points, and amateurs can study methods of construction and installation. Wireless telegraphy and telephony, and long-distance telephony by wire, with loud-speaking transmitters, will all be demonstrated. But the exhibit will not stop at this point. Taking advantage of the amateur's interest, it will lead him back by striking illustrations and by actual experiments to the laboratory of Hertz, who detected wireless waves by their power of producing sparks; the earlier demonstrations of Henry, who recorded the waves sent out by distant lightning and reproduced them experimentally; the researches of Maxwell, who first conceived of waves in the ether when engaged in his mathematical investigations on the electromagnetic theory of light; the pioneer work of Faraday, who visualized lines of force, and conceived the ether as a medium of transmission.

Hitherto the United States has produced few great physicists. Is it not probable that some of these boys will be led to recognize the fundamental importance of science and to see with Carty, Whitney, and other leaders of industry that the greatest advances arise, not merely from the direct attempt of the inventor to solve some special problem, but even more truly from the pioneer work of the scientific investigator, who discovers the phenomena and formulates the laws that underlie and render possible both invention and industry? "You can't have applied science unless you have science to apply," and the industrial research laboratories now move so closely in the wake of the physicist and chemist that the scientific discovery of to-day becomes the working device of to-morrow.

An excellent illustration of this is afforded by the recent development of the audion tube, which has made wireless telephony possible. No better means of interesting the amateur in fundamental problems of physics could be imagined. It is but a step from this familiar device of the radio operator to the brilliant phenomena of the electric discharge that led Crookes to detect a "fourth state of matter" and enabled Thomson, Rutherford, Millikan, and others to discover and isolate the electron and to determine the true nature of matter itself.

THE SUN AND THE AURORA

Another easy transition, helping to broaden the student's vision by showing him the interrelationship of the various branches of science, will lead him from the glowing gases of vacuum tubes to the phenomena of the aurora and their seat in the sun. The colored and pulsating striae of gases at low pressure are produced by passing through them a stream of electrons, resulting from an electric discharge. In the same way the gleam of the aurora arises from the bombardment of the earth's upper atmosphere by electrons shot out from the sun. These come to us continuously, so that the aurora, though too faint to be seen by the eye, can be detected (in Southern California) by the spectroscope on any night, even through clouds. But when great and active sun-spots, surrounded by violent eruptions, are near the centre of the sun, the rain of electrons is enormously increased, and the aurora is brightened into visibility. The electric currents in the higher atmosphere are accompanied by earth currents, which sometimes become so intense that they interfere with telegraphy and even burn out ocean cables (as in May, 1921). A recording magnetograph, mounted near the entrance of the central hall, will show the spasmodic fluctuations in the intensity of the earth's magnetism that accompany these electric storms, and the visitor can observe the source of the electrons by going to the middle of the hall, where a large image of the sun, formed by a coelostat telescope, mounted on the dome above, may be seen on the white surface of the circular drum shown on page 525. The sun-spot responsible for the disturbance will be plainly visible, and its changes in form, as well as its shifting position on the disk caused by the rotation of the sun, can also be followed from day to day.

This takes us to the sun, which exhibits its electrical and magnetic phenomena on a colossal scale in its own atmosphere. The chemical composition of this atmos-

phere is easily shown by the spectroscope within the circular drum at the centre of the hall. Light from the solar image, passing through a narrow slit in the upper face of this drum, descends to an optical grating near the level of the basement floor, is analyzed into its constituent parts, and sent back in the form of a brilliant spectrum. By looking down through an eye-piece near the sun's image the visitor can see this spectrum, crossed by the numerous dark lines that characterize the chemical elements present in the vaporous atmosphere of the sun. Hundreds of these lines are due to iron, easily identified by touching a button, which starts an electric arc, vaporizes its iron poles, and permits the resultant light to descend through the slit, side by side with the light of the sun. The bright lines of iron in the arc, coinciding exactly with the dark lines of iron in the sun, may then be seen at a glance. It will also be possible with this apparatus to show the widening or splitting of certain lines due to the magnetic fields in sunspots, which are caused by swarms of electrified particles whirling in the immense vortices or tornadoes that constitute the spots.

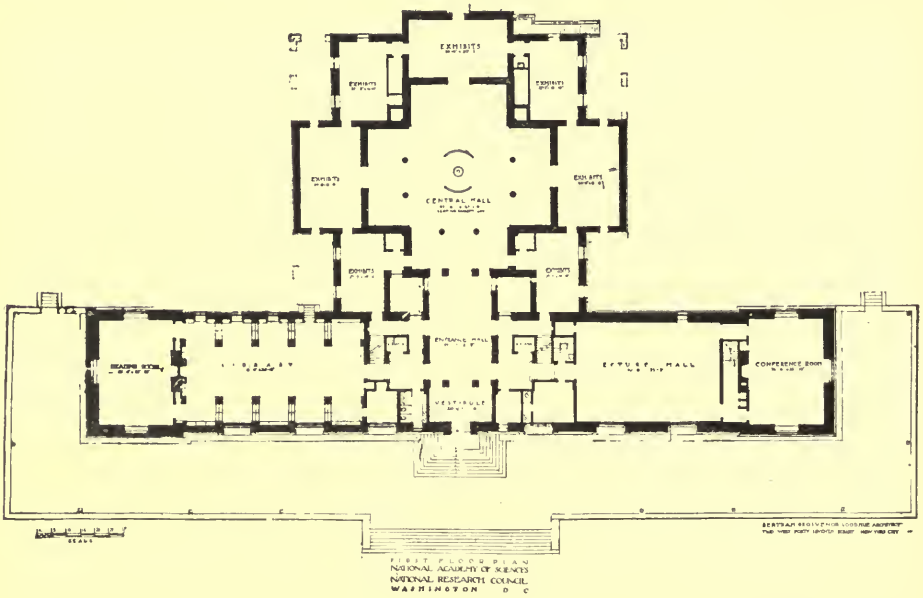
These details will suffice to explain the character and the purpose of the exhibits. Current phenomena of nature, the apparatus for studying them, and the means by which fundamental discoveries are applied for the public welfare will all be demonstrated in a changing exhibit, kept constantly up to date, and covering the whole range of the physical and biological sciences. A great Foucault pendulum, swinging in an invariable plane at the centre of the hall, will illustrate the rotation of the earth turning beneath it. Two small lead balls, drawn toward larger balls by their mutual attraction, will demonstrate the power of gravitation (the Cavendish experiment). A Nichols radiometer, when exposed by a visitor's touch to a bright light, will demonstrate the pressure of radiation, so feeble from even the most brilliant terrestrial sources, but so intense in certain stars that it tends to disintegrate them. The remarkable phenomena of the interference of light, and their use for the most minute and exact measurements of length or for the determination of the diameter of the stars; the beautiful structure and colors of crystals in process of formation, shown with polarized light;

General view of the new building

From a preliminary sketch by the architect

living infusoria, in their exquisite variety, swimming in a drop of ditch-water; growing colonies of bacteria; the phenomena of cell division and of artificial parthenogenesis—these are further examples of the exhibits in the central hall.

One of the smaller exhibits rooms, as already remarked, will be devoted to wireless communication. Another will be placed at the disposal of the scientific and technical bureaus of the government, which will show in sequence the results of their latest researches. Another will be used to illustrate the advances made in industrial research laboratories. The discoveries and progress of physics, chemistry, astronomy, zoology, botany, and other branches of the physical and biological sciences, and of medicine, engineering, and agriculture will be demonstrated in the remaining rooms.



Main-floor plan of the new building of the National Academy of Sciences and National Research Council

SCIENCE AND INDUSTRY

In all their activities, whether in popularizing science, supplying technical information, securing co-operation among investigators, pointing out new possibilities of progress, or promoting the development of American industries, the National Academy and the Research Council must always seek to maintain an effective balance between fundamental science and its applications in the arts. The United States is strong in mechanical skill and prolific in invention. It must become equally successful in the fundamental sciences, where its progress today is more rapid than ever before. Every advance in this direction will be returned tenfold in the industries, where the importance of research is fast gaining recognition. When men like Elihu Root, Theodore Vail, and Herbert Hoover emphasize the fact that industrial development and national progress depend in great degree upon the improvement of methods and the increase of output by research, and when industrial corporations spend millions annually in their research laboratories, we may be sure that the leaders of the industries that still apply old processes will soon awaken. An important division of the Research Council devotes its whole attention to this problem, demonstrating by examples drawn from the practice of leading industries that no expenditure is more profitable than that which is made for research. When this is generally appreciated, and when all of our great corporations realize that they can cheapen

Main entrance of the new building
From a preliminary sketch by the architect

and improve their products by research, a reciprocal advantage to fundamental science will follow. Conscious of their debt to its teachings, and of their never-ceasing need for new knowledge, the industries will provide for its support by adding liberally to the endowment of research laboratories. Educational institutions, where the need for funds is greatest, have already begun to feel the benefit of such support, and it is safe to say that the contributions of the industries will multiply as they prosper in the light of scientific knowledge.

ASPECTS OF SCIENCE

To appreciate the possibilities of the many activities that will focus in this building, and to realize their significance to human progress, we must briefly survey the wide field of science and discern its true place in any intelligent scheme of national development.

Science, dimly discerned among the

mists of antiquity by the Chaldeans and Egyptians, was first clearly recognized by the keen vision of the Greeks, only to be lost again in mediaeval obscurity. Recovered after many centuries and increasingly appreciated as the chief factor in the development of the modern world, science is now held at its true value by all fully enlightened men. Those who have learned from study and research, or perhaps as the result of industrial experience, know science as the one sure guide to the discovery of truth and as the strongest ally of mankind. Others, who have glimpsed only one of its aspects, see science as the cold embodiment of reason, devoid of the beauties of the imagination that exist for them only in literature and art. Those who recognize most clearly its material services to the world think of science as the navigator of the seas, the bearer of man's voice on the ether, the mother of industry. To some, who have seen science disfigured by the violence of the invader, its image has been distorted into a fearful shape of pestilence and fire. And, unfortunately, there are others, from the inquisitors who burned Giordano Bruno and imprisoned Galileo to their modern counterparts, who regard science as the enemy of their particular creeds, and would penalize the teacher of evolution and the student of the origin of man.

But whatever be one's viewpoint, he must be blind indeed if he fails to recognize the services of science to civilization. Man was once in abject fear of nature, and in his superstitious ignorance deified the wind and the thunder, and peopled the air with evil spirits, whom he propitiated by sacrifice. Today, taught by science, he analyzes the lightning, traces its origin in the raindrops, and utilizes its essence in the industrial arts. He navigates the air in the face of furious gales, and dissipates its dreaded mysteries by the light of new knowledge. Instead of fearing nature, he now subdues her to serve his needs. The range of his perception has spread from a little area centering in Greece, surrounded by untracked lands and seas, to the depths of a universe in which he watches the birth, growth, and decay of worlds incomparably greater than his own. He looks back into the remote history of the earth, observes it in its early stages of development from the ancestral sun, and watches the ebb and flow of primeval seas, the growth and emergence of continents, the descent and recession of the polar ice, the slow fashioning by fire and wind and stream of our present home. He finds in the lowest beds of stratified rocks the simple forms of early life, traces the rise of animals and plants through successive strata laid down during millions of years, detects the first signs of the appearance of man, and follows his ascent as his intelligence slowly ripens and at last subdues the earth. He sees him at first rudely fashioning flint implements, and perceives his advance from the stage of simplest invention to the discovery of natural laws which permit him to satisfy not merely his obvious needs, but to attain results which, without science, could not be even conceived. Manifold increase in the production of the soil, the rapid conquest of disease and the lengthening of human life, the creation and development of industries and the reduction in cost of daily necessities, all these and much more we owe to science, whose work for humanity has only just begun.

But it is not only in the material world that science is useful to mankind. Its greatest aim and object is the discovery of the truth, which it pursues without fear of embarrassing consequences. Science sets before us a high example of honest judgment and an open mind, reversing its conclusions without hesitation when new evidence demands. And as it builds up through the centuries, by long and painful search, a great body of knowledge for universal benefit it spreads before the imagination a picture which no artist could hope to rival. Science does not seek a formula with which to reproduce the sculpture of Praxiteles or Rodin, the paintings of Rembrandt or Turner, the poetry of Homer or Keats. It recognizes here, as it does in true religion, a domain beyond its own. But its appeal is to the imagination as well as to the reason. The painter, with common pigments and bristle brushes, creates on canvas a great portrait or landscape. The archi-

The entrance hall

From a preliminary sketch by the architect

tect, with blocks of primeval mud hardened into rock beneath an extinct ocean, builds a great cathedral which stirs us by its majesty. Science, revealing with its instruments of metal and glass the widest sweep of nature, inspires the imagination by vistas of the stellar universe, the exquisite life of the microscopic world, the successive stages in the evolution of the earth and of man. No material service of science to daily life, such as the accurate marking of time or the navigation of the seas, can compare in value with its overthrow of earth-centred mediaevalism and its revelation of the universe. The enlarged conception of human possibilities thus afforded, the escape thus effected from the dominance of enforced and arbitrary thought, are reflected in the advance of the modern world. And the sweeping picture that science spreads before us is unmatched in its appeal to the imagination and its stimulus to progress.

THE ORGANIZATION OF SCIENCE AND RESEARCH

It is not surprising, therefore, that from very early times men have met to discuss the problems of science and to improve their means of research. The Academy of Plato and the great School of Alexandria are striking examples of such associations of scholars in the best days of Greek civilization. In the darkness of the succeeding centuries we find the Arabs pursuing their astronomical, mathematical, and chemical studies in Bagdad, Cairo, and Spain, but in most of Europe stagnation prevailed until Galileo brilliantly demonstrated the theory of Copernicus and forced the earth from its traditional place at the centre of the solar system. From

that time forward academies of science were formed in rapid succession, notably the Accademia dei Lincei in Italy, the Académie des Sciences in France, and the Royal Society in England. In this country the American Philosophical Society, established in Philadelphia through the initiative of Benjamin Franklin, did much to promote the increase and diffusion of knowledge. The American Association for the Advancement of Science began its important work in 1848, and the Congressional charter of the National Academy of Sciences was signed by Abraham Lincoln in 1863.

The reading-room

From a preliminary sketch by the architect

The purpose of the National Academy differs materially from that of the vast number of special societies that have advanced science by the encouragement of specialization. Without them, it is true, science could never have reached its present high development, as its immense range renders concentration on particular problems essential. But in the very nature of the case such concentration develops narrowness of view, and the isolated worker, his whole heart and soul locked within a closely bound field, fails to see clearly the vast territory lying beyond his own. What is needed is the development of men capable of intense specialization, conducted in the light of a broad appreciation of the major problems of science. The specialist is often in danger of becoming dependent upon a single instrument or a narrow range of methods; he should be brought into touch with the great variety of instruments and methods devised by workers in other fields, for in scores of cases they are directly applicable in his own. Take, for example, the case of astrophysics, which began with the study of the physical phenomena of the sun, moon, and planets by simple telescopic observation. The introduction of photography, and the use of the spectroscope, bolometer, thermopile, radiometer, several forms of interferometer, the photo-electric cell, and scores of other instruments borrowed from the physicist have completely transformed the science and

The central hall, showing the Foucault pendulum and the circular drum on which the solar image is projected by the cœlostat telescope on the dome above

From a preliminary sketch by the architect

advanced it by leaps and bounds. So with physical chemistry, physiology, and psychology, all of which have profited in high degree by drawing from the inexhaustible store of physical instruments and methods. The development of experimental medicine is another case in point. But while progressive men in these and many other fields have borrowed freely, and advanced their subjects in like proportion, the possibilities of such modes of progress are as yet but little realized. A body of leading investigators, covering all branches of science and vigorously exchanging ideas, is alone competent to appreciate and profit by them.

Another illustration will show in a

different manner why such a body is needed. Consider the physicist, studying the great problem of the constitution of matter. His present era of unprecedented progress, foreshadowed by Crookes's discovery of "a fourth state of matter" in vacuum tubes, suddenly dawned with the advent of X-rays and radioactive substances. Today the structure of the atom is rapidly becoming evident; the constitution of the elements, by the progressive addition of units of positive and negative electricity, is partly understood; and the decomposition of some of them has been accomplished. But much is yet to be learned, and this can best be done by the intimate collaboration of physicists, chemists, and astrophysicists, who deal with matter in diverse forms, observed under widely different conditions. The enormous temperatures of the stars, the disintegrating effects of radiation pressures greatly transcending those observed on earth, the influence of great solar magnetic fields, and the extraordinary power of stellar gravitation offer to the physicist and chemist the means of trying experiments beyond the range of laboratory possibilities. Here, again, a great academy, bringing such men together and presenting their results from a common forum, can accomplish what no special society can attain.

But it is hardly necessary to illustrate further when the opportunity before such a comprehensive body is so obvious. To maintain, as some still do, that an organization like this is merely a survival, not needed today because of the success of the special societies, is merely to betray a narrowness of view that calls for no comment. The greatest progress of the future will come from men of broad vision, who will appreciate and profit by participation in an academy where members of widely different experience and knowledge unite to advance science in its larger aspects.

THE NATIONAL ACADEMY OF SCIENCES

One of the most striking pen portraits of President Lincoln that we possess depicts him on the great tower of the Smithsonian Institution, which he ascended night after night with Joseph Henry, first secretary of the Institution and charter member of the National Academy of Sciences. From this vantage-point lights were flashed to distant stations, in connection with tests of new methods of signalling. It was in such researches for military purposes that the Academy had its origin.

The period of these experiments was an anxious one. Many months of war, marked by serious and unexpected reverses, had left small room for overconfidence, and taught the necessity of utilizing every promising means of strengthening the Northern arms. With one or two notable exceptions, the great scientific bureaus of the government, now so powerful, had not come into existence. But the country was not without its leaders of science and engineering, both within and without the government circle. Davis, fighting admiral, chief of the bureau of navigation, founder of the *Nautical Almanac;* Bache, superintendent of the Coast Survey, designer of the defenses of Philadelphia; and Joseph Henry, of whom we have already spoken, clearly recognized the need of a national organization, embracing the whole range of science, to advise the government on questions of science and art. Joining with them Louis Agassiz, the great naturalist; Benjamin Pierce, mathematician and astronomer; and B. A. Gould, founder of the Observatory of the Argentine Republic, they planned the National Academy of Sciences. A bill to incorporate the Academy was introduced in the Senate by Senator Wilson of Massachusetts on February 21, 1863. It passed the Senate and the House, and was signed by President Lincoln on March 3. This bill, which was subsequently amended to remove the limitation of membership, and to permit the Academy to receive bequests, named fifty charter members, conferred powers of organization, the election of members, and the transaction of business, and provided that "the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art . . . ."

As the adviser of the government on questions of science the Academy was

immediately called upon by the War and Navy Departments to report on various problems connected with the Civil War. The Academy thus assisted in the national defense just as the Paris Academy of Sciences aided in resisting invasion and stamping out civil war after the French Revolution.

But it is only in great emergencies that such a body is justified in turning aside from its real task of advancing knowledge and benefiting industry. Thus, the Civil War ended, the Academy assumed with relief its normal duties. These were numerous and pressing, for science in this country was in great need of development. In 1831 de Tocqueville had seen but little evidence of the progress of science in the United States, and even in 1873 Tyndall recognized few important accomplishments. But under the active leadership of Academy members the way was preparing for the rapid advances of later years.

In accordance with the provisions of the charter, the government continued to call upon the Academy for advice on a great variety of problems. During the following years reports were submitted on such questions as the transit of Venus, instructions for the *Polaris* expedition, surveys of the Territories, electrical units, the conduct of scientific work under the government, the protection of coal mines from explosion, the erection of a new naval observatory, the inauguration of a national forest policy, scientific explorations of the Philippines, and scores of other problems. Some of these requests for advice were submitted by the President, others by acts of Congress, joint commissions of Congress, and the various departments of the government. Some of the information thus supplied by the Academy can now be obtained from the numerous scientific bureaus and national laboratories of the government. But it still remains true that questions of broad scope, especially those requiring the co-operation of scientific authorities representing several fields of knowledge, can be best dealt with by such an independent and unbiassed body as the National Academy. An illustration of this is afforded by the organization of the National Research Council.

THE NATIONAL RESEARCH COUNCIL

The sinking of the *Lusitania* in 1915 destroyed all possible doubt of Germany's intention to wage a ruthless war regardless of the United States. Action by the Academy was at once considered, but no favorable opportunity occurred until April, 1916, after the wanton attack on the *Sussex*. The President immediately accepted the Academy's offer of service, and requested it to organize the scientific agencies of the United States in the interest of the national defense, but with the ultimate object of advancing scientific and industrial progress.

The National Research Council, resting legally on the Academy's congressional charter, and comprising in its membership the chiefs of the technical bureaus of the Army and Navy and other scientific bureaus of the government, representatives of educational institutions and research foundations, and representatives of industrial and engineering research, was accordingly constituted by the Academy with the active co-operation of the principal national scientific and engineering societies. The prominent part played by the Engineering Foundation, which devoted its entire income toward the expense of organization, gave the services of its secretary, and provided a New York office for the Research Council, is a noteworthy illustration of the cordial support given by the engineers.

The Research Council was organized on September 20, 1916, and immediately took up its duties. It was accordingly well under way when the United States entered the war in the following April, and thus lost no time in getting into action. Its chairman had learned something of the war services of the British and French men of science while in Europe in the summer of 1916, and its committee to secure active co-operation with them was one of the first American agencies sent abroad after our declaration of war. Subsequently Scientific Attachés, selected by the Research Council and accredited by the State Department to our embassies in London, Paris, and Rome, provided the necessary means of keeping our activities in close

touch with those of our allies. With the aid of scientific investigators and naval officers reciprocally sent to our Washington headquarters by Great Britain, France, and Italy an extensive study of the problem of locating submerged submarines was organized in co-operation with the navy, and rapid progress was soon made in devising and perfecting new devices for this purpose. Hundreds of other problems were also successfully attacked in co-operation with the War and Navy Departments. These are far too numerous for mention here, as may be seen by referring to the third annual report of the National Research Council, where the war activities of its various divisions are briefly outlined. A noteworthy service was the initiation in the army of the extensive series of psychological tests, actually applied to some 1,700,000 men and since the war widely adopted for college entrance examinations and in the selection of men by the industries. This illustrates how work undertaken to meet war needs can be utilized in times of peace.

PEACE SERVICES OF THE NATIONAL RESEARCH COUNCIL

An executive order issued by the President of the United States on May 11, 1918, after stating that the work accomplished by the National Research Council during the war demonstrated its capacity for larger service, requested the Academy to perpetuate the Council, and defined its peace duties as follows:

In general, to stimulate research in the mathematical, physical, and biological sciences, and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare.

To survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects.

To promote co-operation in research, at home and abroad, in order to secure concentration of effort, minimize duplication, and stimulate progress; but in all co-operative undertakings to give encouragement to individual initiative, as fundamentally important to the advancement of science.

To gather and collate scientific and technical information at home and abroad, in co-operation with governmental and other agencies, and to render such information available.

The executive order also stated that for the purpose of assuring the cordial co-operation of the scientific and technical branches of the government the President would continue to appoint representatives on the nomination of the National Academy of Sciences, and would arrange for the further co-operation of the respective heads of government departments.

Under the democratic plan of organization adopted after the Armistice, the National Research Council consists of the representatives of fifty-six scientific and technical societies, together with representatives of the government and certain members at large. I wish that space permitted me to describe its numerous activities since the war. It is only possible, however, to give a few typical illustrations of methods and results. Take, for example, the work of the Council in promoting research in the fields of physics and chemistry, which lie at the very foundation of science and industry. Committees are formed of the leading investigators of the chief problems of physics. These committees meet from time to time to compare methods and results, and to prepare broad surveys of the existing state of knowledge and the most promising opportunities for further research. Many of these monographs have been published by the Council, thus rendering the committees useful not merely in stimulating their members, widening their outlook, and securing informal co-operation, but also in placing the results of their surveys before other investigators. Another mode of advancing research is illustrated by the establishment of National Research Fellowships in physics and chemistry. The Rockefeller Foundation, recognizing the fundamental character of these sciences and the importance of developing a large number of students competent to advance them by research,

gave the council $100,000 a year for five years to provide liberal fellowships for those who have shown exceptional promise in their university work. The results of this experiment, which has been in progress for three years, have been so satisfactory that the Rockefeller Foundation and the General Education Board have just united in a second gift of $500,000 to the Council, to establish similar fellowships in medicine. Still another means of helping investigators is through assistance in securing loans of scientific instruments. The Division of Physical Sciences, learning of the unusual resources of some laboratories and the pressing needs of others, serves with the Research Information Service as useful go-between. Ultimately the Academy and Council will be able to lend many instruments from their own collection, resulting from the return of apparatus purchased by recipients of grants from their special research funds.

These examples must suffice to typify the diverse work of the various divisions of science and technology of the Research Council, which also include those of engineering, chemistry and chemical technology, geology and geography, medical sciences, biology and agriculture, anthropology and psychology.

The Lincoln Memorial, as seen from a point near the new building of the National Academy of Sciences and National Research Council

While the cases cited and many more relate to fundamental problems of science, others are severely practical, such as the fatigue phenomena of metals, high-speed tool steels, moulding sands, electric insulation, fertilizers, food and nutrition, forestry, child welfare. The Council, in co-operation with the Department of Agriculture and many State organizations, maintains a central bureau for highways research, as a clearing-house and means of co-ordination of the activities of State agencies, which are spending hundreds of millions for the construction of roads. Another recent accomplishment of the Council in a different field, due to the energetic and effective

The Washington Monument, as seen from the Lincoln Memorial
The dome of the Capitol, in the distance, is covered by the monument

service of its Permanent Secretary, Doctor Vernon Kellogg, is the provision of large funds received through the Rockefeller Foundation for the support of the Concilium Bibliographicum, which otherwise would have been forced to suspend its valuable work of indexing and abstracting the extensive literature of biology.

The Divisions of General Relations of the Research Council supplement those of science and technology. Thus the Division of Federal Relations brings together representatives of the scientific and technical bureaus of the government for the consideration of common problems, and the Division of States Relations seeks to promote the scientific and technical work organized under the authority of the various States. The Division of Foreign Relations represents the United States in the International Research Council, which was organized soon after the armistice in harmony with a plan presented by the National Academy of Sciences at meetings held in London and Paris under the auspices of the Royal Society and the Paris Academy of Sciences. The Division of Educational Relations studies the conditions for research in American educational institutions and seeks means of discovering and developing exceptionally qualified students. The Research Information Service collects data needed by research workers and answers scientific and technical questions received from any source. A glance through its files reveals the great variety of inquiries received from scientific investigators, state and government bureaus, industrial laboratories, students, private workers, and others. If funds can be obtained to develop the Information Service adequately, incalculable assistance and great saving of time and expense can be afforded to men of science, the industries, and the general public.

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Membership and Organization.—The National Research Council is a coöperative organization of scientific men of America, including also a representation of men of affairs interested in engineering and industry and in the "pure" science upon which the applied science used in these activities depends. Its membership is largely composed of accredited representatives of about seventy-five national scientific and technical societies.

The Council was established at the request of the President of the United States, under the Congressional charter of the National Academy of Sciences, to coördinate the research facilities of the country for work on war problems involving scientific knowledge. In 1918, by Executive Order, it was reorganized as a permanent body. Although partly supported during the war period by the government and primarily devoted at that time to its activities, the Council now derives all of its financial support from other than governmental sources and is entirely controlled by its own representatively selected membership and democratically chosen officers. It maintains, however, a close coöperation with government scientific bureaus and their activities.

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